Measurement of Spin of Projectiles

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ABSTRACT

Hitherto the spin of the projectile has been measured with the help of spin loop method (for magnetised projectiles) and Multishot Ballistic Synchro method (for magnetised and non-magnetised projectiles). This paper discusses the method of measurement of spin with a single ballistic synchro picture; the advantage of this method is that it dispenses with elaborate and precise optical alignment, required for Multishot Ballistic Synchro method.

1. INTRODUCTION

The rate of spin of a projectile is an important parameter in the design of any spin stabilised projectile. One of the common experimental method used hitherto has been the spin loop method in which a magnetised projectile is projected in a long loop loop of wire and the resultant output recorded on an oscilloscope from which the spin is found. This method was quite cumbersome and very often is not applicable for projectiles with non-ferrous bodies like rockets and missiles. With the advent of high speed cameras, it is now possible to measure the spin accurately at any point of the trajectory at low angles and upto about 100 m from the muzzle. The photographic method has the advantage that it can measure low spin rates and does not require magnetisation of the projectile.

A high speed streak camera used in the ballistic synchro mode has been so far used for measuring the spin. In this technique, the speed and direction of the film in the camera is adjusted to match the speed and direction of the image which is virtually made static on the film. A spiral painted projectile has to be photographed at two points for computing the spin of the projectile. This involved the method of beam spliting and use of an optical bench. Fig. 1 shows the experimental set up for taking

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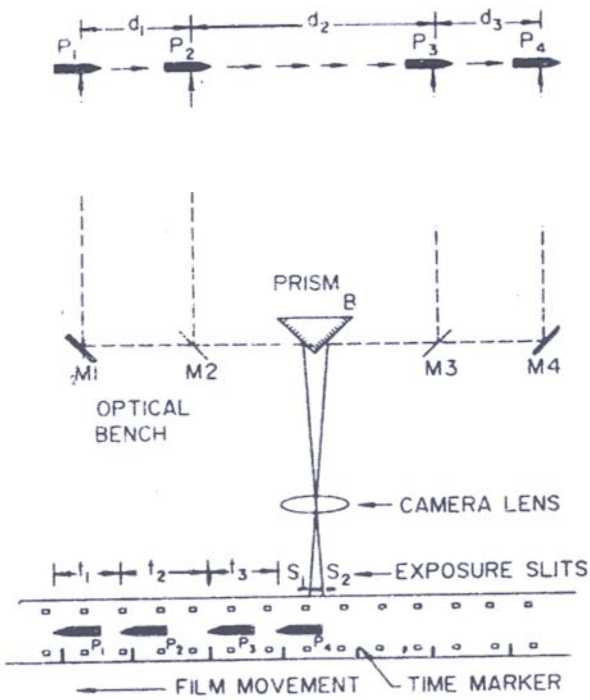

Figure 1. Experimental set-up for taking four ballistic system pictures.

four ballistic synchro pictures. The positioning of optical bench has a serious limitation in that, when the spin is to be measured near the muzzle of a high velocity launcher the entire set up is thrown away by the muzzle blast. Although alignment of optical bench could easily be achieved under laboratory conditions but it is very difficult to achieve precise alignment with the optical bench set up under field conditions. In

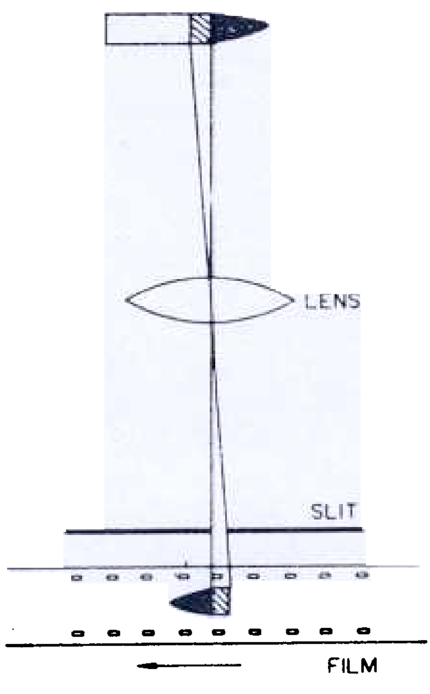

Figure 2. Experimental set-up for taking one ballistic synchro picture.

order to overcome the difficulties, we have evolved a new method in which no optical bench is used and spin is computed from a single photograph with only straight black and white lines painted on the projectile. Fig. 2 shows an experimental set up for taking one ballistic synchro picture. In this method the projectile is painted with alternate black and white stripes on the straight cylindrical portion. The painting should be done with care so that the lines are sharp and straight as the accuracy of measurement very much depends on this. Fig. 3 shows the photograph of a painted

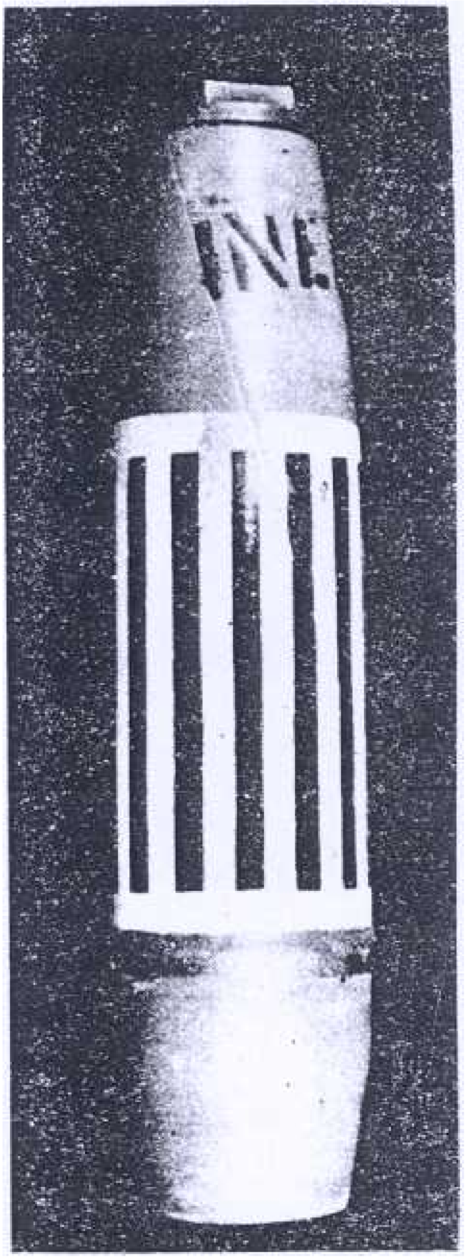

Figure 3. Photograph of a plainted projectile.

projectile. The projectile is launched and a ballistic synchro picture using a single high speed streak camera is taken. Fig. 4 shows a high speed streak picture of spinning projectile in flight. In the ballistic synchro technique different portions of the projectile are photographed at different intervals of time contrary to ordinary photography where the different parts of projectile are photographed at the same instant.

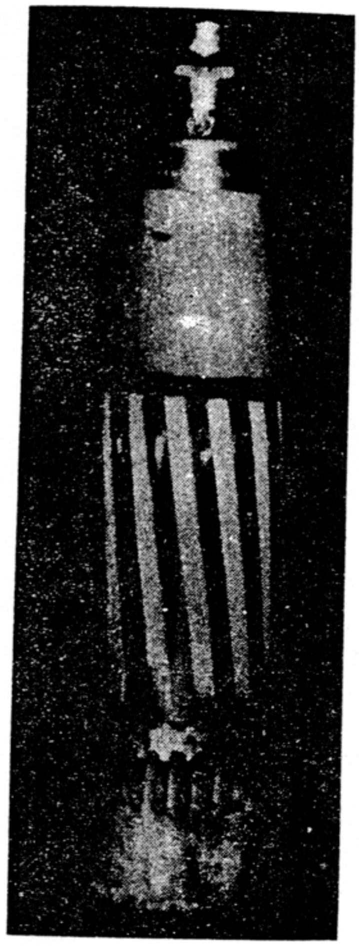

Figure 4. High speed streak photograph of the spinning projectile in flight.

2. ANALYSIS

A straight line on a spinning cylindrical body moving perpendicular to the slit of the streak camera appears inclined due to the time taken by it to cross that slit. The inclined line being on the surface of a cylinder will appear to be curved on image plane. Thus when the projectile moves across the slit of streak camera, any line *LM* drawn parallel to the axis of the projectile will appear curved as in curve *LN* at Fig. 5, due to the transverse transport of points on account of the spin. The two points

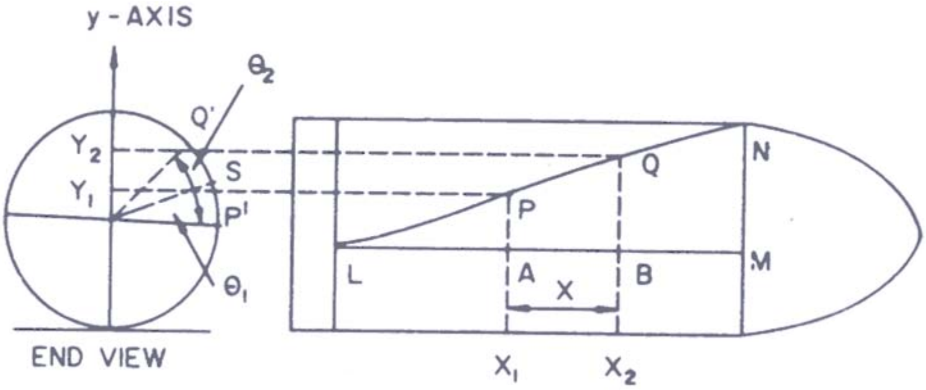

Figure 5. Schematic diagram showing the behaviour of a straight line on a spinning and moving projectile as it crosses the slit.

P and Q on the curve LN therefore correspond to two points A and B on the line LM. Let the co-ordinates of P and Q be (X_1, Y_1) and (X_2, Y_2) respectively on the curve LM. Then in the time taken by the projectile to travel the distance $X = X_2 - X_1$ the point P' has travelled to Q' a distance S along the circumference of the projectile. The distance $Y = Y_2 - Y_1$ gives the projection of the arc $P'Q'$ in the diameter as shown in Fig. 5.

Angular velocity $= (\theta_2 - \theta_1)/t$

Where $\sin\theta = (Y-R)/R$

$RPS = (\theta_2 - \theta_1)/2\pi t$

where θ is in radian

As the image radius R, distance Y and time t to travel a distance X can be measured from the film, the revolutions per second made by the projectile can be computed very accurately.

3. RESULTS

While the expected value of spin as calculated from the velocity and rifling is 113 revolutions per second, the values as obtained by using the above method in the case for identical projectiles are 113.44, 113.72, 112.53, 116.4.

This method has the limitations in the case of high velocity, slow spinning projectiles due to negligible rotation of the projectile in time t.

REFERENCES

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